

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and reviewing the collection of information, sending comments regarding this burden estimate or any other aspect of this collection of information, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Avenue, Washington, DC 20540, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

AD-A223 514

2. REPORT DATE
May 29, 1990

3. REPORT TYPE AND DATES COVERED
Final 12/01/88 - 03/31/90

Final Report: Equipment Grant No. AFOSR-89-0172
"(DURIP), Testing and Data Acquisition/Control Equipment
for Soil Dynamics and Geotechnical Centrifuge Laboratory"

5. FUNDING NUMBERS
AFOSR-89-0172

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REPORT NUMBER

AEOSR-JR- 90 0664

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
AFOSR/NA
Bldg. 410
Bolling AFB, DC 20332-6448

10. SPONSORING/MONITORING
AGENCY REPORT NUMBER

AFOSR-89-0172

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

A description of equipment purchased under an AFOSR equipment grant is provided. This equipment is being used to extend the capabilities of the existing MTS servo-hydraulic axial-torsional testing machine to allow high precision tests on hollow cylinder soil specimens at constant mean stress levels, especially for specimens undergoing very small strains. The principal equipment items acquired are a computer based data acquisition and control system, a new hollow cylinder triaxial cell, a number of transducers and associated electronics, and mechanical hardware, including a new hydraulic power supply. In addition, several equipment items have been acquired with the RPI matching funds for the existing 100 g-ton geotechnical centrifuge, including a container for holding models during testing and a fork lift for model transport. Keywords: Laboratory/test equipment;

14. SUBJECT TERMS

Soil Mechanics;
Hollow Cylinder Tests;
Data Acquisition and Control System;

Geotechnical Centrifuge;
Soil Dynamics; (E D C) 4
Constitutive Relation

15. NUMBER OF PAGES
5

16. PRICE CODE

17. SECURITY CLASSIFICATION
OF REPORT
UNCLASSIFIED

18. SECURITY CLASSIFICATION
OF THIS PAGE
UNCLASSIFIED

19. SECURITY CLASSIFICATION
OF ABSTRACT
UNCLASSIFIED

20. LIMITATION OF ABSTRACT

Final Report:

Equipment Grant No. AFOSR-89-0172

Ricardo Dobry and Emmanuel Petrakis, Principal Investigators

This is the final technical report of Air Force Grant AFOSR-89-0172 on "Testing and Data Acquisition/Control Equipment for Soil Dynamics and Geotechnical Centrifuge Laboratory," prepared in accordance with the terms and conditions set forth in the grant documents. The grant was made in order to purchase data acquisition and control and related equipment for the existing MTS Servohydraulic Axial-Torsional Testing Machine. This machine has been and will continue to be an extremely important and productive research tool in the RPI Soil Dynamics Laboratory. The equipment purchased from this grant extends the capabilities of the MTS to allow closed loop, constant mean stress tests at very small strains. Additionally, several equipment items were purchased for the 100 g-ton Geotechnical Centrifuge using RPI's contribution as part of the cost-sharing agreement with AFOSR. Following are: A) description of the equipment purchased, and B) description of current and possible future projects in which the equipment is being or will be used.

A) EQUIPMENT PURCHASEDItem #1: Data Acquisition/Control System

A new computer-controlled data acquisition and control system was purchased for the existing MTS axial/torsional testing machine. Originally a system manufactured by Hewlett Packard was to be acquired for this purpose. However, since the proposal was written, there has been a significant improvement in the capabilities of general use PC-type computers with a simultaneous reduction in their prices. It was therefore decided to purchase a PC-based system since these are more cost-effective, more versatile (with a wide variety of available software and hardware), and are easily integrated with the other PC computers existing in the Civil Engineering Department.

The system finally purchased consists of:

— a Zeos 80386-25 computer	\$13,323
— Metra Byte data acquisition boards	1,530
— software for data acquisition	1,808
— a Zeos 80286-20 computer	6,738

Total Cost: \$23,399

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Item #2: Hydraulic Power Supply

A hydraulic power supply was purchased to supply hydraulic power to and to allow simultaneous independent operation of the existing MTS testing frame and the new high pressure frame. The equipment purchased is:

- a Double A 5 gpm Hydraulic Pump \$ 2,707
- plumbing supplies and installation 1,300

Total Cost: \$ 4,007

Item #3: Transducers, Conditioners, Amplifiers for existing MTS Device

A number of high quality transducers and related components were purchased including

- Precision Measurements Co. pore pressure transducers \$ 480
- a high precision load cell from Dardis Co. 929
- a precision displacement transducer from MTS 1,054
- a number of general purpose amplifiers manufactured by Analog Devices 604
- Belden shielded electronic cable 182

In addition, several new high performance upgrades to the existing MTS servo-electronics and servo-hydraulics were purchased to allow very small strain testing. This equipment was purchased from MTS and amounted to

\$ 6,368

Total Cost: \$ 9,617

Item #4: Hollow Cylinder Triaxial Cell

This cell was designed and manufactured at RPI, which accounts for the significant reduction in the cost of this item compared with the original proposal.

Total Cost: \$ 3,862.

Item #5: Adjustable Height Table

A scissors-type jack table was purchased for moving the triaxial cell.

Total Cost: \$ 675

Item #6: Miscellaneous Electronic and Computer Hardware

A number of electronic and computer related items have been purchased:

- a SUN graphics monitor	\$ 679
- a Paradise Professional graphics card with software	695
- an Everex modem, Log-tech mouse, and utility software	490
- an HP Laserjet upgrade	700
- computer RAM, cables, miscellaneous software and hardware	568
- a SCADA analysis program	1,248
- a Panasonic camera	956
- a Magnum Opus programmable electronic microcontroller	337
- a Fluke digital multimeter	298
- a Sola regulated electronic power supply	120
- an American Megatrends status and display terminal	2,291
- miscellaneous electronic tools, including a G.C. Soldering Station	578

Total Cost: \$ 8,960

Item #7: Miscellaneous Laboratory Hardware

Several general purpose laboratory items were purchased:

- a set of Craftsman tools	\$ 1,388
- a Sola electronic DC power supply	287
- a number of special-purpose hand tools	582
- tubing and pressure fittings for the triaxial test cells	533
- miscellaneous supplies	720

Total Cost: \$ 3,510

Item #8: Hardware for Geotechnical Centrifuge Device (RPI Matching Funds)

A strongbox used to contain soil models during centrifuge testing was fabricated for \$4,800. A Crown forklift used to carry the heavy centrifuge models into and out of the centrifuge was partially funded (\$2,820) with monies from this grant. In addition, a general purpose CAD program, Tango Cad, sold by Accel Technologies, was purchased @ \$703 to facilitate the design and fabrication of equipment for the laboratory as a whole.

Total Cost: \$ 8,323

Summary of Equipment Purchased:

Item #1	\$23,399
Item #2	4,007
Item #3	9,617
Item #4	3,862
Item #5	675
Item #6	8,960
Item #7	3,510
Item #8	<u>8,323</u>
	\$62,353

B) RESEARCH PROJECTS

The equipment acquired is already being used in several RPI research projects and will be used extensively in the future, as follows:

"Constitutive and Micromechanical Stress-Strain Modelling of Granular Soil," current project supported by Grant AFOSR-89-0350. The experimental part of this work, consisting of axial and torsional constant mean stress loading of hollow-cylinder specimens of glass beads, has already used much of the MTS upgrade listed in Item #3, as well as some of the hardware and software of Item #1. Future tests will make even more extensive use of this equipment and of other pieces included in Items # 2, 6 and 7, and will incorporate the hollow cylinder triaxial cell and height table listed in Items #4 and 5. In the numerical simulation part of this project, consisting of 2-D discrete element runs using program CONBAL-2, the Zeos 80386-25 computer of Item #1 has been extensively used. In the next few months, this same computer will be utilized in the project for some additional runs with new 3D program CONBAL-3.

"Study of Stress-Strain Behavior of Granular Soils by Numerical Experiments Using Random Arrays of Elastic Spheres," current project supported by NSF Grant MSM-8817212. In this project, a 3D version of discrete element program CONBAL (CONBAL-3) was very recently developed. Although most of the work was done in the Cornell Supercomputer, a number of runs were also performed in the Zeos 80386-25 computer listed in Item #1.

A research proposal has been submitted to INTEVEP (Venezuelan Petroleum Institute) for numerical simulations of oil sands under loading, using program CONBAL. It is anticipated that the Zeos 80386-25 computer will be used in this work.

Finally, reference should be made to several current and expected research and equipment projects related to the RPI Geotechnical Centrifuge, which either make use of or supplement the centrifuge hardware of Item #8. They include:

- "Geotechnical Centrifuge Research at RPI," (NCEER, current).
- "1990 Presidential Young Investigator Award to Prof. A. Elgamal of RPI," (NSF, current).

- "Research Equipment: Testing and Data Acquisition Equipment for Geotechnical Centrifuge Laboratory," (NSF, current).
- "Development of an Earthquake Ground Motion Simulation for Geotechnical Centrifuge Facility," (NSF, pending).
- "Verification of Liquefaction Analysis by Centrifuge Studies," (NSF, pending).